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DOCUMENT-IDENTIFIER: US 6582777 B1
TITLE: Electron beam modification of CVD deposited low dielectric constant materials

Brief Summary Text (9):
The reduction of the dielectric constant of the film must maintain the physical properties of the films, while improving their electrical properties, such as reducing failures due to early dielectric breakdowns, enhancing performance as an insulator, and reducing the presence of unwanted electrical charges within the material lattice. Previous attempts to reduce the dielectric constant of CVD films required very long heating times. For example, the dielectric constant of fluorine doped SiO.sub.2 has been reduced by thermally processing the material at 400.degree. C. in Nitrogen for at least 60 minutes. There is an accompanying film shrinkage with this treatment. It has now been found that by applying an electron beam to the CVD deposited material, a reduction in both peak process temperature and total process time may be achieved. The application of the electron beam to the CVD material may induce radical formation and a modification of the material such that the desired film properties can be achieved. It has been unexpectedly found that the dielectric constant of the CVD deposited materials may be reduced by the electron beam process to a value below that attainable by conventional thermal processing. The electron beam is applied at an energy sufficient to treat the entire thickness of the CVD material. The total dose applied would be determined by the desired film properties necessary for the implementation of the specific CVD low-k material. The electron beam process would be carried out at a temperature necessary to achieve the desired properties in the CVD low-k material. Because of the diverse nature of the current CVD low-k materials, and the potential development of future CVD low-k materials, the electron beam process conditions will depend on the particular material under consideration. Thus, a dielectric constant of 3.0 or below can be achieved depending on the composition of the film. This would provide a cost advantage to device manufacturers because they can extend their existing oxide CVD equipment with minimal cost.

Brief Summary Text (10):
The present invention applies an electron beam treatment to the CVD film to reduce the dielectric constant of the film. Because the electrons can penetrate the entire thickness of the film, they can modify the properties through the bulk of the film. The electron beam also modifies oxide films which leads to a more stable film.

Brief Summary Text (30):
The film is then treated by exposing it to a flux of electrons to modify, i.e. cure, polymerize, crosslink or anneal the layer. Such a treatment is performed by placing the coated substrate inside the chamber of a large area electron beam exposure system, such as that described in U.S. Pat. No. 5,003,178 to Livesay, the disclosure of which is incorporated herein by reference. The exposing is conducted by overall flood exposing substantially the entire thickness of substantially the whole area of the layer to electron beam radiation all at once. The period of electron beam exposure will be dependent on the total dosage applied, the electron beam energy applied to the film and the beam current density. One of ordinary skill in the art can readily optimize the conditions of exposure. Preferably the electron beam exposure is done in vacuum in the range of from about 10.sup.-5 to about 10.sup.2 Torr, and with a substrate temperature in the range of from about 10.degree. C. to about 400.degree. C., more preferably from about 30.degree. C. to about 400.degree. C. and most preferably from about 200.degree. C. to about 400.degree. C. The